SEA WAVES ENERGY HARVESTER BASED ON IMPACTS

Carlos Viñolo, Antoni Mànuel, Joaquin del Rio, Daniel Toma
SARTI Research Group. Electronics Dept. Universitat Politècnica de Catalunya (UPC). Rambla Exposició 24, 08800, Vilanova i la Geltrú. Barcelona. Spain.+(34) 938 967 200

Abstract
The main problematic about electronic systems deployed in the sea for long periods of time, is to find a feasible way to supply them with the necessary amount of power without the necessity of a periodical supervision. Small systems, such as sensors that belong to a net of milliwatts consuming devices extended in a wide area, cannot be wire-fed because of the inconveniences it might create, and they usually include a battery that cannot be on-field recharged. For this reason, energy harvesting is considered a great solution in order to create independent, self-sufficient, wireless and small underwater systems. One of the possible ways to obtain energy within, and directly from the sea, is taking advantage of the naturally created sea movements. This paper discusses this innovational idea and presents some worked out laboratory tests.

Keywords *– Energy Harvesting, Disk Piezoelectric, Sea Waves Energy, Sensor Net, Impact Energy.*

INTRODUCTION

In the last decade, piezoelectric elements have been studied and their use has been increased exponentially due to their inherit characteristic of converting mechanical energy into electrical power, thus having a good application within the energy harvesting field. Harvest energy from the sea is nothing new, and different proposals and projects have been implemented [4]-[6] to use the tidal and wave movements to generate electricity such as the Pelamis Wave Power from the E-On company [1]. The proposed idea in this paper is not aimed to generate big amounts of electricity, but just enough power to feed small sensors and wireless devices using low-cost piezoelectric elements in a maritime medium. Instead of the popular bending piezo-element used in a wide bunch of papers [2], disk piezoelectric.

When used as generators, an AC waveform is created every time the disk is deformed (a pressing force is applied) and recovers its original shape (the force is released). To create an autonomous press-release system, a mass is suspended between two piezoelectric disk elements using a flexible material so the force applied to the disks depends on the weight of the mass and the acceleration, created by the change of the movement direction in every hit and delivering part of the kinetic energy to the piezoelectric element. Figure 1 shows the proposed box containing two disk piezos, the electronics to harvest the energy and the bending plate/bar with the built-in mass. In this case, this system would be applied to power underwater sensors so the change of movement is created by the up and down swinging of the sea waves.

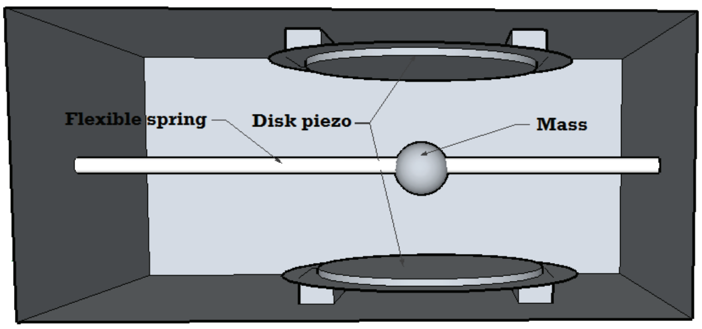

Fig.1 Schematic of the purposed system

The benefits of this system against the usual bending elements are the low cost and the possibility of encapsulate the disks and electronics in a robust waterproof box. In addition, there is no need to work close to the resonant frequency of the piezoelectric since power is harvested from every hit, thus the one-hit obtained energy is independent from the frequency. This is suitable for low-frequency environments where other methods do not really have a good performance, as happened in our other investigations about under-water vortex harvesting [3].

APPLICATION

The purpose of this idea is to power low-consumption instruments or devices that are deployed into the sea. Most accurately, the aim of this system is to power the different nodes of autonomous-wireless sensors of an underwater sensor net, where energy harvesting is a key idea to use these nets for long periods of time.

Because the electrical wire from the power source to the device should be as short as possible to reduce cost and losses, the piezoelectric disk based energy harvesting system is deployed next to the device that is going to feed. Since the devices are usually attached to the sea-ground, the mechanical movement has to be brought from the sea surface to the bottom where is going to be harvested and converted to electrical energy. Figure 2 shows a schematic of how this can be achieved using a buoy and a rigid wire that holds the cage containing the energy harvesting system. When the buoy moves up with the force of a wave, the cage is pulled in the same direction creating an acceleration that moves the mass hitting the disks. To push the cage down again, a spring can be attached to the base of it to the sea-ground so if the buoy goes down, the spring will create a big acceleration in the cage in the opposite direction making the mass hit the other disk.

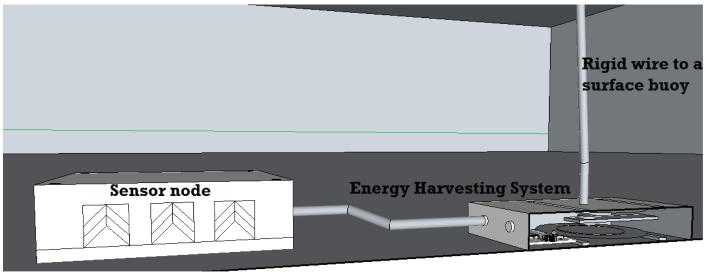

Fig. 2 Schematic of the application

TESTS AND CONCLUSIONS

A first model has been built to test small disk piezoelectric elements working as generators and hit by a lead ball. A pendulum-based structure has been built holding the ball with a cord and two disks in every side. Each disk has a diameter of 1.5cm. The AC output of the piezoelectrics, connected in parallel, is the input of a MAX17710 Evaluation Kit, featuring a diode bridge and a very high performance Energy Harvesting converter that stores the charge in an ultra-thin battery.

Using the pendulum-based design the output of both piezoelectrics connected in parallel is measured waving the structure carefully in a constant rate. Figure 3 shows the result, having big positive and negative peaks because the piezo elements were connected inversely. The voltage amplitude of each hit is around 16V and the frequency between one hit and another in the same piezoelectric is f=1.4Hz.

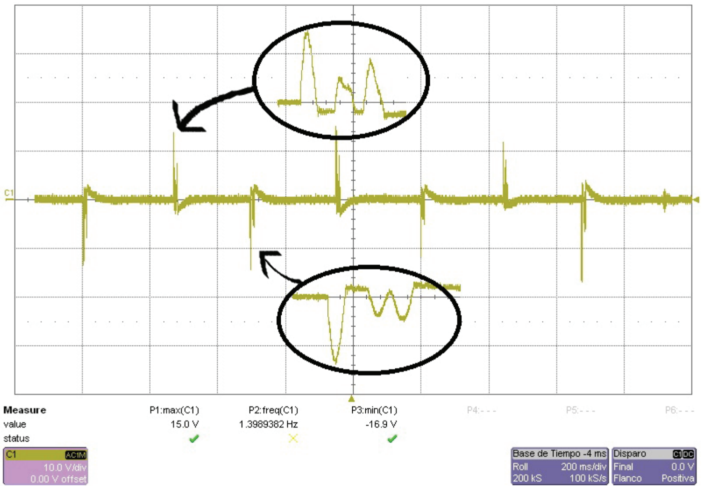

Fig. 3 Output of the disk piezo elements in the pendulum-based model

Fig.4 Deployed buoy attached to the sea observatory OBSEA for new tests in real conditions.

For real testing, a buoy has been deployed into the sea (figure 4) and the power generated will be measured at the surface with the harvesting system under the water. This will determine if this method is efficient enough to power sensor nodes or any other electronic devices working under or over the sea water. The results obtained on the first lab tests are grateful for a further research.

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